A novel, automated nutrition screening system as a predictor of nutritional risk in an oncology day treatment unit (ODTU)

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Purpose: Paper-based nutrition screening tools can be challenging to implement in the ambulatory oncology setting. The aim of this study was to determine the validity of the Malnutrition Screening Tool (MST) and a novel, automated nutrition screening system compared to a 'gold standard' full nutrition assessment using the Patient-Generated Subjective Global Assessment (PG-SGA).

Methods: An observational, cross-sectional study was conducted in an outpatient oncology day treatment unit (ODTU) within an Australian tertiary health service. Eligibility criteria: ≥18 years, receiving outpatient anticancer treatment and English literate. Patients self-administered the Malnutrition Screening Tool (MST). A dietitian assessed nutritional status using the PG-SGA, blinded to the MST score. Automated screening system data were extracted from an electronic oncology prescribing system. This system used weight loss over three to six weeks prior to the most recent weight record or age-categorised Body Mass Index (BMI) to identify nutritional risk. Sensitivity and specificity against PG-SGA (malnutrition) were calculated using contingency tables and Receiver Operating Curves.

Results: N=300 oncology outpatients (51.7% male, 58.6 ± 13.3 years). The area under the curve (AUC) for weight loss alone was 0.69 with a cut-off value of ≥1% weight loss yielding 63% sensitivity and 76.7% specificity. MST (score ≥2) resulted in 70.6% sensitivity and 69.5% specificity, AUC 0.77.

Conclusions: Both the MST and the automated method fell short of the accepted professional standard for sensitivity (~≥80%) derived from the PG-SGA. Further investigation into other automated nutrition screening options and the most appropriate parameters available electronically is warranted to support targeted service provision.

Keywords: Nutrition screening, Sensitivity, Specificity, Malnutrition, Cancer, Automated

Introduction

It is widely acknowledged that malnutrition is under-diagnosed and under-treated in patients with cancer. Nutritional status influences morbidity, response to or tolerance of treatment, quality of life, hospital admission rates, and health care costs [1-3]. The prevalence of cancer-related malnutrition has been reported to be as high as 80% [4-13]; figures likely influenced by divergent definitions of malnutrition, tumour type and stage, as well as treatment regimen [14].

Evidence-based guidelines for the management of malnutrition [15] in relation to patients with cancer [16, 17] recommend routine nutrition screening to identify 'at risk' patients using a tool validated in the oncology setting. Nutrition screening is used to quickly and easily identify high risk patients for subsequent referral to an appropriately trained clinician (usually a dietitian) for a comprehensive nutrition assessment and management plan [18]. Nutrition assessment involves a more detailed investigation considering medical and nutritional history, as well as objective anthropometric parameters to determine an individuals' nutritional status [13]. In oncology, the Scored Patient-Generated Subjective Global Assessment (PG-SGA) is commonly used for nutrition assessment. The PG-SGA was developed for use with cancer patients and has been validated within ambulatory oncology settings [13, 12, 19]. However, given the cost (time and manpower) of nutritional assessment, it is not practical for all oncology outpatients to undergo nutritional assessment, hence the need for nutritional screening.

Traditional manual nutrition screening tools are currently favoured as a feasible method of rapidly identifying individuals at risk of malnutrition. However, despite being relatively less labour intensive than nutritional assessment, manual nutrition screening still requires staff time to undertake, to record results and to communicate referral to a dietitian. The Malnutrition Screening Tool (MST), has demonstrated good validity and reliability in identifying patients at risk of malnutrition in the oncology setting [8], and is commonly used to routinely screen for nutritional risk in patients with cancer in Australia. However, with growing patient numbers and limited staff resources, nutrition screening is often not prioritised in the outpatient setting, resulting in referrals being delayed or only made for those with visible physical signs of malnutrition [20]. In a recent audit of the Oncology Day Treatment Unit (ODTU) within this facility, 26% of patients undergoing outpatient anticancer treatment were malnourished; alarmingly, 22% had received no prior dietetic contact [21]. With the prospect of additional staffing to perform nutrition screening in this setting unlikely, despite a clear need for it, embedding screening within existing technology platforms was a viable alternative to explore. To our knowledge, there have been no studies in the oncology setting that have investigated an automated nutrition screening system.

This study aimed to develop a novel, automated nutrition screening system and validate it against a full nutrition assessment using the Patient Generated-Subjective Global Assessment (PG-SGA) tool. A secondary aim was to compare the sensitivity and specificity of the automated screening system with that of the patient-administered MST.

Materials and methods

Study Design

This was a single site, cross sectional, observational study. All participants provided informed consent before participation. The protocol received approval by the Metro South Human Research Ethics Committee.

Subjects

A convenience sample of eligible, consecutive patients was offered study entry. Eligibility criteria included aged 18 years or greater, receiving outpatient anticancer treatment, English literate and able to provide written consent.

Data Collection

Data were collected over a six-week period, Monday-Friday, during April-May 2013. Patient descriptive information on age, gender, cancer diagnosis, chemotherapy treatment protocol, chemotherapy cycle and day, previous treatments, concurrent treatment and year of diagnosis were collected from the participant's medical records. Data pertaining to prior cancer-related dietetic contact (i.e., location, date, current status in the dietetic system) were obtained from medical records and clarified with the patient or the treating dietitian. Cancer diagnoses were collapsed into six categories; breast, gastrointestinal, haematological, head and neck, lung and other.

MST

The MST is a nutrition screening tool [22], found to have acceptable inter-rater reliability (*kappa*=0.03; *P <0.001)* when administered by dietitians, medical staff, nurses, administration staff and by patients themselves [8]. It comprises two questions relating to recent unintentional weight loss and poor eating as a consequence of decreased appetite. The tool provides a score between zero to five, with patients classed as 'at risk' of malnutrition if the score is equal to or greater than two [22]. Patients in this study self-administered a written MST and placed it into an envelope for collection by researchers. The data collectors were blinded to the patients' MST prior to undertaking their separate PG-SGA assessment.

PG-SGA

The PG-SGA consists of a medical and dietary history (weight loss, dietary intake, nutrition impact symptoms, functional capacity, metabolic stresses) and a physical assessment (subcutaneous fat, muscle atrophy and oedema). Height, weight, and weight history data were obtained from patients' medical records, where possible. As in clinical practice, if these were unavailable, self-reported data were used. The PG-SGA produces the following global ratings; well nourished (SGA A), moderately malnourished (SGA B) or severely malnourished (SGA C) [20, 23]. The tool gives a total score (0-50), typically ranging from zero to thirty five [24]. In the oncology setting, patients will score a minimum of one, with one point allocated on the basis of proven malignancy. Scores greater than nine indicate a critical need for nutrition-related symptom management [20]. The PG-SGA was undertaken on each participant once during a scheduled chemotherapy treatment. PG-SGA assessments were undertaken by two dietitians. Inter-rater reliability was assessed by duplicate ratings of several patients prior to commencement of data collection. The lead investigator reviewed all PG-SGA assessments and if agreement in the global rating and score was not reached, a senior researcher, blinded to both the MST and automated screening results independently reviewed the data to determine the PG-SGA rating.

Automated Screening System

All chemotherapy regimens within this facility are prescribed, manufactured, supplied, and administered by way of the electronic prescribing system/medical record Charm^{TM} software (charmhealth, Pty Ltd, V4.2.4). This electronic system supports the multidisciplinary team by providing patient-centric cancer treatment information at the point of care. A report was generated from the electronic system data that included name, age, patient identification number, measured weight (recorded from electronic scales, to the nearest 0.1kg), measured height (recorded from a single wall-mounted stadiometer, to the nearest 0.01m) and Body Mass Index (BMI). The data from the electronic system that were used for comparison with PG-SGA consisted of weight loss data and BMI. BMI was calculated and categorised based on age; i.e., <65 years underweight (<18.5 kg/m^2), normal range (18.5-24.9kg/m^2), or overweight/obese (≥25 kg/m^2) [25]; ≥65 years underweight (<22 kg/m^2), normal range (22-29.9kg/m^2), or overweight/obese (≥30kg/m^2) [26]. Weight was measured at periodic medical review appointments prior to chemotherapy administration. Weight loss was calculated over a three to six week period prior to the most recent weight record in the electronic system. In the case of multiple weight records within this timeframe, the record closest to thirty days was used. BMI was used only if a weight change record was unavailable e.g., only for patients new to chemotherapy or if weight was recorded outside the identified time period.

Data analysis

Data were entered into STATA version 13.0 [27]. Receiver operating characteristic (ROC) curves and contingency tables were generated to determine the sensitivity (percentage of malnourished correctly identified as such in comparison to the PG-SGA) and specificity (percentage of well-nourished correctly identified as such compared to the PG-SGA). Positive predictive values (PPV) and negative predictive values (NPV) (i.e., the likelihood that the tool accurately predicts the presence or absence respectively of malnutrition) of the automated screening system compared to the PG-SGA were also calculated. This was similarly done for the MST. For the purpose of statistical analyses, nutritional status was classified as two groups; 'well-nourished' (SGA A) and 'malnourished' with SGA B and SGA C merging.

Results

General characteristics of study participants

Table 1 outlines the general characteristics of study participants. 312 eligible patients were identified with 300 consenting (96.2% participation). Reasons for non-participation included chemotherapy-associated fatigue and minimal remaining time of the chemotherapy infusion. The mean participant age was 58.6 ± 13.4 years and 51.7% were male (n=155). The most common cancer diagnoses were haematological (31.3%), followed by gastrointestinal (21%) and breast cancers (19.7%).

Nutritional status and BMI

Using the PG-SGA global rating, 83% (n=249) of participants were well-nourished (PG-SGA A) and 17% (n=51) were malnourished (SGA B n=46; SGA C n=5) (Table 1). Malnourished patients had significantly lower body weight and BMI than well-nourished patients (*P= <0.001).* Malnutrition varied between diagnoses (*P= 0.039),* with 37.5% of head and neck patients being malnourished, followed by 27% of those with

gastrointestinal malignancies, 14.9% with haematological diagnoses, 12% with lung and 10.2% with breast malignancies. More than half the participants (53%, n=159) were overweight or obese for their age, whilst 7% (n=21) were underweight.

Performance of the automated nutrition screening system and MST compared to PG-SGA

Table 2 outlines the results. According to the MST, 37.2% (n=112) of patients were at risk of malnutrition (score ≥2). The MST had a 70.6% sensitivity and 69.7% specificity compared to the PG-SGA. For the automated system, weight change data were available for 245 patients, age-categorised BMI was available for 40 patients without weight change data, and 15 patients had no weight and height data recorded. Different cut-offs were used for these variables within the automated tool to determine the best sensitivity, specificity, predictive values and accuracy compared to the PG-SGA. Using cut-offs of weight loss of ≥1% in three to six weeks or age-categorised underweight BMI, these variables provided 30.6% sensitivity and 71.6% specificity compared to the PG-SGA. When BMI was removed (n=245), the sensitivity of weight loss of ≥ 1% was 63.0% and specificity was 76.7%.

Discussion

The best performing automated screening criteria using a combination of weight loss and underweight BMI (≥1% weight loss in three to six weeks or age-categorised underweight BMI) showed reasonable specificity but low sensitivity against the full nutritional assessment by the PG-SGA. Once underweight, age-categorised BMI was removed, the sensitivity and specificity using the ≥1% cut off value improved, however still failed to reach the accepted professional standard of 80%. We therefore cannot recommend any of the automated screening system methods in their current format. Further research into the most appropriate electronic parameters is warranted. It is worth exploring a wider time period for weight changes, as the one utilised in this study may have been too short. Furthermore, given that underweight age-categorised BMI alone performed poorly in sensitivity, this particular automated system may only have potential in monitoring patients who are at risk of malnutrition once they are well established on treatment.

The literature supports nutritional screening within the oncology population. However, studies to date have focused on manual, paper-based screening methods. This is the first study to investigate the effectiveness of an automated nutrition screening system to assess nutritional risk in the ambulatory oncology outpatient population. Research however has progressed in other clinical areas. In the surgical setting, Smith et al. [28] used Brugler's simplified screening tool for malnutrition-related complications (MRCS) to rank six variables (three biochemical parameters, wound presence, presence of high risk illness, and poor nutritional intake) to enable automated screening in hospitalised patients. The MRCS proved to be the more predictive of postoperative complications compared to the SGA. The MRCS however has not been investigated outside the acute surgical setting and might not be transferable to the ambulatory oncology setting.

Although the MST performed better than the automated system in this study, it also fell short of the accepted professional standard for sensitivity (~80%) against the PG-SGA. Other studies of oncology populations have reported more acceptable sensitivity and specificity when comparing the MST to the PG-SGA. For example,

Isenring et al. [8] reported 100% sensitivity and 92% specificity in 50 oncology outpatients with mixed diagnoses, while Ferguson et al. [29] reported 100% sensitivity and 81% specificity in 106 oncology outpatients undergoing radiotherapy. Gabrielson et al. [4] reported 81.3% sensitivity and 72.4% specificity in 90 chemotherapy outpatients with mixed diagnoses. The lower sensitivity in our study could be related to the MST being self-completed. Despite this tool being relatively quick and easy, its administration by clinicians in this particular outpatient setting has not been possible due to limited human and financial resources.

According to the PG-SGA global rating, the prevalence of malnutrition in this study was 17%. Other studies of smaller samples using the SGA or PG-SGA identified malnutrition prevalence in oncology outpatients receiving chemotherapy around 25% [8, 21]. A larger variation in malnutrition prevalence was found using the SGA or PG-SGA in oncology outpatients undergoing radiotherapy, with findings between 11-35% [24, 29]. Despite the reduction in malnutrition at this site compared to a previous audit [21], 41.2% of malnourished patients in the present study (n=21) were not known to the dietetic system, confirming the need for formalised nutrition screening in this setting.

The strengths of this study are that nutritional assessments were conducted by dietitians blinded to nutritional screening results, the relatively large sample size, the representative sample of patients recruited, and the excellent participant response rate. Limitations include no weight and height data being available for 5% (n=15) of patients undergoing anti-cancer treatment in the study.

Conclusion

With the direction of medical records trending towards electronic systems, the investigation of automated or computerised nutrition screening systems is timely. Nonetheless, challenges do exist. Electronic medical record systems can provide benefits in terms of efficiency, safety and timely access to information; however, there are notable risks if they are not properly implemented, maintained or used. Whilst the present study did not demonstrate acute weight change within a three to six week period to be a valid screening method, it will inform future research into novel automated screening tools to manage the vast numbers of cancer patients receiving chemotherapy to support targeted dietetic service provision. Suggestions for future studies are to explore the most clinically-relevant electronic nutritional parameters.

Disclosures

The authors declare that we have no conflicts of interest. We acknowledge that we have full control of all primary data and agree to allow the journal to review the data if requested.

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Statement of authorship

All authors read and approved the final manuscript. JA carried out the study and prepared the manuscript. JA and LT were responsible for conception and study design, statistical analysis and interpretation. DM assisted with technical design of the automated software. EI, LT, AM, DM provided interpretation and critical revision of the article. JA and JW participated in the acquisition of data and literature review. EI supervised the study.

References

1. Gout BS, Barker LA, Crowe TC (2009) Malnutrition identification, diagnosis and dietetic referrals: Are we doing a good enough job? Nutrition & Dietetics 66:206-211. doi:doi:10.1111/j.1747-0080.2009.01372.x
2. Ravasco P, Grillo IB, Camilo M (2007) Cancer wasting and quality of life react to early individualized nutritional counselling! Clin Nutr 26:7-15. doi:doi:10.1016/j.clnu.2006.10.005
3. Humphreys S, Pellissier J, Jones A (2013) Cost-effectiveness of an aprepitant regimen for prevention of chemotherapy-induced nausea and vomiting in patients with breast cancer in the UK. Cancer Manag Res 5:215-224. doi:10.2147/cmar.s44539
4. Gabrielson DK, Scaffidi D, Leung E, Stoyanoff L, Robinson J, Nisenbaum R, Brezden-Masley C, Darling PB (2013) Use of an abridged scored Patient-Generated Subjective Global Assessment (abPG-SGA) as a nutritional screening tool for cancer patients in an outpatient setting. Nutr Cancer 65 (2):234-239. doi:10.1080/01635581.2013.755554
5. Creaser N (2010) Nutritional status of oncology patients admitted to a rural day chemotherapy unit as measured by the Patient Generated-Subjective Global Assessment. Nutr Diet 67:231-236
6. Leuenberger M, Kurmann S, Stanga Z (2010) Nutritional screening tools in daily clinical practice: the focus on cancer. Support Care Cancer 18 Suppl 2:S17-27. doi:10.1007/s00520-009-0805-1
7. Read JA, Choy ST, Beale PJ, Clarke SJ (2006) Evaluation of nutritional and inflammatory status of advanced colorectal cancer patients and its correlation with survival. Nutr Cancer 55 (1):78-85. doi:10.1207/s15327914nc5501_10
8. Isenring E, Cross G, Daniels L, Kellett E, Koczwara B (2006) Validity of the malnutrition screening tool as an effective predictor of nutritional risk in oncology outpatients receiving chemotherapy. Supportive Care in Cancer 14 (11):1152-1156
9. Segura A, Pardo J, Jara C, Zugazabeitia L, Carulla J, de Las Penas R, Garcia-Cabrera E, Luz Azuara M, Casado J, Gomez-Candela C (2005) An epidemiological evaluation of the prevalence of malnutrition in Spanish patients with locally advanced or metastatic cancer. Clin Nutr 24 (5):801-814. doi:10.1016/j.clnu.2005.05.001
10. Read JA, Crockett N, Volker DH, MacLennan P, Choy STB, Beale P, Clarke SJ (2005) Nutritional assessment in cancer: comparing the Mini-Nutritional Assessment (MNA) with the scored Patient-Generated Subjective Global Assessment (PGSGA). Nutr Cancer 53 (1):51-56. doi:10.1207/s15327914nc5301_6
11. Laviano A, Meguid MM, Rossi-Fanelli F (2003) Cancer anorexia: clinical implications, pathogenesis, and therapeutic strategies. Lancet Oncol 4 (11):686-694
12. Bauer J, Capra S (2003) Comparison of a malnutrition screening tool with subjective global assessment in hospitalised patients with cancer--sensitivity and specificity. Asia Pac J Clin Nutr 12 (3):257-260
13. Bauer J, Capra S, Ferguson M (2002) Use of the scored Patient-Generated Subjective Global Assessment (PG-SGA) as a nutrition assessment tool in patients with cancer. Eur J Clin Nutr 56 (8):779-785
14. Vandebroek AJV, Schrijvers D (2008) Nutritional issues in anti-cancer treatment. Ann Oncol 19 Suppl 5:v52-55
15. Watterson C, Fraser A, Banks M, Isenring E, Miller M, Silvester C, Hoevenaars R, Bauer J, Vivanti A, Ferguson M (2009) Evidence based practice guidelines for the nutritional management of malnutrition in

adult patients across the continuum of care. Nutrition & Dietetics 66:S1-S34. doi:10.1111/j.1747-0080.2009.01383.x

16. Isenring E, Zabel R, Bannister M, Brown T, Findlay M, Kiss N, Loeliger J, Johnstone C, Camilleri B, Davidson W, Hill J, Bauer J (2013) Updated evidence-based practice guidelines for the nutritional management of patients receiving radiation therapy and/or chemotherapy. Nutr Diet. doi:10.1111/1747-0080.12013
17. Bauer J, Ash S, Davidson WL, Hill JM, Brown T, Isenring EA, Reeves M (2006) Evidence based practice guidelines for the nutritional management of cancer cachexia. Nutr Diet 63:S3-S32. doi:10.1111/j.1747-0080.2006.00099.x
18. Skipper A, Ferguson M, Thompson K, Castellanos VH, Porcari J (2012) Nutrition screening tools: an analysis of the evidence. JPEN J Parenter Enteral Nutr 36 (3):292-298. doi:10.1177/0148607111414023
19. Isenring E, Bauer J, Capra S (2003) The scored Patient-generated Subjective Global Assessment (PG-SGA) and its association with quality of life in ambulatory patients receiving radiotherapy. European Journal of Clinical Nutrition 57 (2):305-309. doi:10.1038/sj.ejcn.1601552
20. Ottery FD (2000) The clinical guide to oncology nutrition. Patient generated subjective global assessment. The American Dietetic Association, Chicago, IL, USA
21. Davidson W, Teleni L, Muller J, Ferguson M, McCarthy AL, Vick J, Isenring E (2012) Malnutrition and Chemotherapy-Induced Nausea and Vomiting: Implications for Practice. Oncol Nurs Forum 39 (4):398-398. doi:10.1188/12.onf.e340-e345
22. Ferguson M, Capra S, Bauer J, Banks M (1999) Development of a valid and reliable malnutrition screening tool for adult acute hospital patients. Nutrition 15:458-464
23. Detsky AS, McLaughlin JR, Baker JP, Johnston N, Whittaker S, Mendelson RA, Jeejeebhoy KN (1987) What is subjective global assessment of nutritional status? JPEN J Parenter Enteral Nutr 11 (1):8-13
24. Isenring EA, Capra S, Bauer JD (2004) Nutrition intervention is beneficial in oncology outpatients receiving radiotherapy to the gastrointestinal or head and neck area. Br J Cancer 91 (3):447-452. doi:10.1038/sj.bjc.6601962
25. National Health and Medical Research Council (2003) Clinical Practice Guidelines for the Management of Overweight and Obesity in Adults. Commonwealth of Australia, Canberra, Australia
26. Bannerman E, Miller MD, Daniels LA, Cobiac L, Giles LC, Whitehead C, Andrews GR, Crotty M (2002) Anthropometric indices predict physical function and mobility in older Australians: the Australian Longitudinal Study of Aging. Public Health Nutrition 5 (5):655-662
27. StataCorp. 2013. Stata Statistical Software: Release 13. College Station, TX: StataCorp LP
28. Smith RC, Ledgard JP, Doig G, Chesher D, Smith SF (2009) An effective automated nutrition screen for hospitalized patients. Nutrition 25 (3):309-315. doi:10.1016/j.nut.2008.09.007
29. Ferguson ML, Bauer J, Gallagher B, Capra S, Christie D, Mason B (1999) Validation of a malnutrition screening tool for patients receiving radiotherapy. Radiat Oncol 43:325-327

Table 1 Clinical variables for cancer patients as classified by SGA global rating

Variable	**All patients**	**Well nourished patients (SGA A)**	**Malnourished patients (SGA B+C)**	***P* value**
Patients [N, (%)]	300 (100)	249 (83)	51 (17)	
Sex [*n*, (%)]				
Male	155 (51.7)	123 (79.4)	32 (20.6)	0.113[+]
Female	145 (48.3)	126 (86.9)	19 (13.1)	
Age (y)	58.6 ± 13.4	58.9 ± 13.1	56.6 ± 13.8	0.253[#]
Type of cancer[a] [*n*, (%)]				
Breast	59 (19.7)	53 (89.8)	6 (10.2)	0.039[+]
Gastrointestinal	63 (21)	46 (73)	17 (27)	
Haematological	94 (31.3)	80 (85.1)	14 (14.9)	
Head and neck	16 (5.3)	10 (62.5)	6 (37.5)	
Lung	50 (16.7)	44 (88)	6 (12)	
Other	18 (6)	16 (88.9)	2 (11.1)	
Weight (kg)	79.3 ± 20.4	82.3 ± 20.5	64.9 ± 12.1	<0.001[#]
BMI (kg/m^2)	27.8 ± 6.8	28.9 ± 6.7	22.6 ± 4.5	<0.001[#]

[a]Cancer diagnosis: 'Gastrointestinal' cancer included colorectal (n=35), oesophageal (n=10), pancreatic (n=8), gastric (n=3), gall bladder (n=2), cholangiocarcinoma (n=2), duodenal (n=2), and appendiceal (n=1) cancers. 'Haematological' diagnoses included lymphoma (n=52), multiple myeloma (n=23), leukaemia (n=18), myelodysplastic syndrome (n=1). 'Other' cancers included: sarcoma (n=6), prostate cancer (n=4), carcinoma of unknown primary (n=2), renal cell carcinoma (n=2), germ cell tumour (n=2), medullablastoma (n=1), and seminoma (n=1).

[+]Comparing well nourished to malnourished patients using chi-squared test

[#]Comparing well nourished to malnourished patients using independent sample *t* test

Table 2 Area under Receiver Operating Characteristic Curves, sensitivity, specificity, predictive values and accuracy in predicting malnutrition assessed by the PG-SGA rating (SGA B/C) (N=300)

Screening method vs. PG-SGA	**Sensitivity (%)**	**Specificity (%)**	**Positive Predictive Value**	**Negative Predictive Value**	**Area Under Curve (95% CI)**	**Accuracy (%)**
≥1% weight loss in 3-6 weeks or underweight BMI^^#	30.6	71.6	18.3	83.3		
Underweight BMI^	18.4	94.9	42.9	84.8		
≥1% weight loss in 3-6 weeks	63.0	76.7			0.69 (0.61-0.76)	74.4
MST ≥2	70.6	69.5			0.77 (0.72-0.82)	69.7

^ <65 years of age, BMI <18.5kg/m^2; ≥65 years of age, BMI <22kg/m^2

#BMI was only used if weight loss data was unavailable

PG-SGA = Patient-Generated Subjective Global Assessment; CI = Confidence Interval; BMI = Body Mass Index, MST = Malnutrition Screening Tool.